

STATUS OF RIVER JEWELWING
(*Calopteryx aequabilis* Say)
IN BRITISH COLUMBIA

by
S.G. Cannings, RPBio



B.C. Ministry of Water, Land and Air Protection
Biodiversity Branch
Victoria BC

B.C. Ministry of Sustainable Resource Management
Conservation Data Centre
Victoria BC

Wildlife Bulletin No. B-110

March 2003

Wildlife Bulletins

Wildlife Bulletins can contain preliminary data, so conclusions based on these may be subject to change. Bulletins receive some review and may be cited in publications. Copies may be obtained, depending upon supply, from the Ministry of Water, Land and Air Protection, Biodiversity Branch, Victoria, BC.

National Library of Canada Cataloguing in Publication Data

Cannings, Sydney G. (Sydney Graham), 1954-

Status of River jewelwing (*Calopteryx aequabilis* Say) in British Columbia

(Wildlife bulletin ; no. B-110)

Co-published by Ministry of Sustainable Resource Management, Conservation Data Centre.

Also available on the Internet.

Includes bibliographical references: p.

ISBN 0-7726-4956-1

I. River jewelwing - British Columbia. 2. Calopterygidae - British Columbia. 3. Damselflies - British Columbia.

I. British Columbia. Biodiversity Branch. II. British Columbia. Conservation Data Centre. III. Title.

IV. Series: Wildlife bulletin (British Columbia. Biodiversity Branch) ; no. B-110.

QL520.3.C3.C36 2003 595.7'33 C2003-960085-8

© Province of British Columbia 2003

This publication is available at <http://wlapwww.gov.bc.ca/wld/documents/statusrpts/b110.pdf>

Citation

Cannings, S.G. 2003. Status of River Jewelwing (*Calopteryx aequabilis* Say) in British Columbia. B.C. Minist. Water, Land and Air Protection, Biodiversity Branch, and B.C. Minist. Sustainable Resour. Manage., Conservation Data Centre, Victoria BC. Wildl. Bull. No. B-110. 10pp.

DISCLAIMER

"In cases where a Wildlife Working Report or Bulletin is also a species' status report, it may contain a status recommendation from the author. The Province, in consultation with experts, will determine the official conservation status and consider official legal designation. The data contained in the status report will be considered during those processes."

ABSTRACT

The River Jewelwing, *Calopteryx aequabilis* Say, is a large, spectacular damselfly restricted in British Columbia to a single site, Christina Creek. This short stream is the warm, clear outlet of Christina Lake and flows into the Kettle River, 18 km east of Grand Forks. Populations are not large; a maximum of 28 adults have been counted on one date. Western populations of the species are quite spotty and this population is probably isolated from the nearest ones in Washington State. The Kettle River has not been well surveyed; there is an unconfirmed sighting from that river near Grand Forks.

The jewelwings are unusual among damselflies in having male courtship displays. Females lay eggs in floating or underwater vegetation, and larvae develop for two or three years before emerging as adults.

Because this species was only discovered at Christina Creek in 1999, there is no information on population trends. The habitat is still predominantly natural, but threats or potential threats include exotic fish, riparian habitat development or degradation, pollution, and habitat disturbance by recreational boaters. The unique qualities of Christina Creek should be recognized when any management plans are developed for the watershed or local area.

ACKNOWLEDGEMENTS

A number of people contributed to this document, all of whom deserve many thanks. I would like to especially thank Dennis Paulson for his contributions of data, photographs and knowledge. Steve Valley, Richard Cannings, Robert Cannings and Leah Ramsay also gave freely of their knowledge and experience, and Ron Walker sent me valuable information regarding the habitat situation along Christina Creek. Robert Cannings and Leah Ramsay reviewed the drafts and made a number of helpful comments and suggestions. Nick Donnelly kindly sent me a draft version of his dot map of North American distribution.

Publication of this species status report was made possible through the funding assistance of Forestry Innovation Investment, MSRM and MWLAP.

TABLE OF CONTENTS

1	SPECIES INFORMATION.....	1
1.1	Name and Classification.....	1
1.2	Description.....	1
2	BIOLOGY	2
2.1	General	2
2.2	Phenology	2
2.3	Reproduction.....	2
2.3.1	Territorial behaviour/Aggressive interactions	2
2.3.2	Courtship behaviour	2
2.3.3	Copulation	2
2.3.4	Oviposition	3
2.4	Survival	3
2.5	Physiology	3
2.6	Movements/Dispersal	3
2.7	Nutrition and Interspecific Interactions.....	3
2.8	Behaviour/Adaptability.....	3
3	HABITAT	3
3.1	Habitat Requirements	3
3.2	Trends in Habitat Quality and Quantity	3
3.3	Present Habitat Status.....	3
3.4	Protection/Ownership	3
4	DISTRIBUTION.....	4
4.1	Global/North American	4
4.2	British Columbia.....	5
5	POPULATION SIZES AND TRENDS	5
5.1	Population Size	5
5.2	Population Trends	6
6	LIMITING FACTORS AND THREATS.....	6
6.1	Limiting Factors.....	6
6.2	Habitat Loss/Degradation	6
6.3	Pollution/Pesticides.....	6
6.4	Exotic Species.....	7
6.5	Recreation Impacts	7
7	SPECIAL SIGNIFICANCE OF THE SPECIES	7
8	EXISTING PROTECTION OR OTHER STATUS.....	7
9	RECOMMENDATIONS AND MANAGEMENT OPTIONS	7
9.1	Inventory and Research	7
9.2	Riparian Zone Management	7
9.3	Recreation Management	8
9.4	Introduced Species Management.....	8
9.5	Pollution Control	8
10	EVALUATION.....	8
10.1	Conservation Data Centre Ranking.....	8
10.2	Summary	8

11 AUTHORITIES CONSULTED.....	9
12 LITERATURE CITED.....	9

LIST OF FIGURES

Figure 1. Male <i>Calopteryx aequabilis</i>	1
Figure 2. Rangewide distribution of <i>Calopteryx aequabilis</i>	4
Figure 3. Known county distribution of <i>Calopteryx aequabilis</i> in the western United States	5
Figure 4. British Columbia distribution of <i>C. aequabilis</i> (Christina Creek)	6

1 SPECIES INFORMATION

1.1 Name and Classification

Calopteryx aequabilis Say, 1839, is a member of the Calopterygidae, a small family of 159 species and 16 genera worldwide, represented in North America by only nine species in two genera. Damselflies in this family are variously known as "jewelwings" (Cannings 2002) or "broad-winged damselflies" (Westfall and May 1996). The genus *Calopteryx* contains 29 species and is represented in North America by five species (Westfall and May 1996; Schorr et al. 2002). *C. aequabilis* is the only representative of its family in British Columbia (Cannings 2002). The name *Calopteryx* can be translated as "beautiful wings." The specific epithet, *aequabilis*, is somewhat more difficult to translate. A Latin dictionary translates it as "uniform, like, similar or equal," but what Say had in mind is obscure.

Some isolated western populations have been described as races, based on differences in wing markings, but these taxa have not been generally recognized. However, further study may reveal them to be valid subspecies (Westfall and May 1996).

A synonym of *Calopteryx* Leach is *Agrion fabricius*; a number of earlier authors, including Walker (1953), treated this species as *A. aequabile*.

Specific synonyms:

aequabilis californicum Kennedy, 1917;
aequabilis coloradicum Cockerell, 1913;
aequabilis yakima Hagen, 1889;
hudsonica Hagen, 1875;
virginica Selys, 1853.

1.2 Description

This is the most spectacular damselfly in British Columbia (Figure 1). It is not only the province's largest species (both males and females are about 47 mm long), but both males and females sport metallic green bodies and coloured wings. The males' bodies have blue reflections in the metallic green, and their wings are clear at the base with broad, dark brown apical bands. Females usually have dark brown wing tips as well, but their wing bases are shaded yellow-brown and their pterostigmas are a bright, contrasting white (Westfall and May 1996; Cannings 2002). In British Columbia, they are the only damselflies with patterned wings. The larvae can be distinguished from those of other damselflies by their greatly elongate first antennal segment, which is as long as the combined length of the remaining segments (Westfall and May 1996). Their lateral gills are also triangular in cross section, in contrast to the flat lateral gills of other damselflies (Westfall and May 1996).



Figure 1. Male *Calopteryx aequabilis*. Photo: D. Paulson.

2 BIOLOGY

2.1 General

Larvae develop underwater, feeding on invertebrates while clinging to submerged vegetation. Preliminary data from Martin (1939) indicated that the larval life was two or even three years long. In his study, the number of larval instars was usually 12, occasionally 13. Adults mature for about five days following emergence (Conrad and Herman 1990), feeding on aerial invertebrates. They then concentrate on reproductive activities.

2.2 Phenology

In British Columbia, the flight period has not been well documented, but probably lasts from mid June until early September (Cannings 2002). No River Jewelwings were observed at Christina Creek on 15 June (2002), but on 19 July (1999), 25 males and three females were counted. By 7 August (1999) the numbers were waning; only six males and three females were counted (L.R. Ramsay, unpubl. data). Oviposition was observed on 17 August (1999), but this was near the end of the flight season—only two males and one female were observed on this date (Cannings et al. 1999; L.R. Ramsay, pers. comm.). In Washington State, the recorded flight period is 6 June to 2 September (Paulson 1999). In a detailed Nova Scotia study, the flight period seems to be slightly earlier—one season began on 29 May, peaked on 11 June and ended on 13 August (Conrad and Herman 1990).

2.3 Reproduction

2.3.1 Territorial behaviour/Aggressive interactions

Males establish and defend a territory containing one or more potential oviposition sites and at least one perch that overlooks the oviposition sites (Corbet 1999); males may return to a specific perch over a number of days (Conrad and Herman 1987). In a Nova Scotia mark-recapture study, males were site-specific, but occasionally moved long distances between captures (Conrad and Herman 1990).

Aggressive interactions are common between

territorial males; they occur over water, usually less than 1 m above the surface. Interactions documented by Conrad and Herman (1987) include: 1) Chase and Escape, in which the intruder is chased until he leaves the territory; 2) Escort Flight, in which the resident flies beside, slightly below and about 30-35 cm from the intruder, until the intruder is escorted to the territory boundary; 3) Circular Battle, an intense mutual circular chase near a territorial boundary that may result in a physical clash; and 4) Reverse Threat, a short-lived action in which an intruder, upon re-entering his territory, faces away from the pursuer and flies from side to side in an arc of about 35 cm, distinctly defining the territorial border.

2.3.2 Courtship behaviour

When a female approaches, the male performs a pair-forming display in front of her, perching on an oviposition site or, if that is submerged, on the water surface above it. The expression of this display varies within both populations and species of *Calopteryx* (Meek and Herman 1990). In the cross display, he faces the female and curls the tip of his abdomen dorsally, exposing the whitish ventral surface of the terminal segments. His hindwings nearly or barely touch the water and his forewings are held above his body (Conrad and Herman 1987). During the cross display of *C. splendens*, the male's fore and hind wings beat alternately and the wing beat frequency increases four-fold (Georg Rüpell obs., cited in Corbet 1999). In about 13% of these displays, the male *C. aequabilis* includes a dive display, in which he floats downstream with hind wings flat on the water; this demonstrates to the female both the location and the quality of the oviposition site (Conrad and Herman 1987; Corbet 1999). Males perform the cross and dive displays only in front of flying females; perched or egg-laying females are harassed until they fly (Conrad and Herman 1987). Despite these complex displays, signals can be misinterpreted; interspecific copulation and oviposition have been observed between *C. aequabilis* and *C. maculata* (Bick and Bick 1981).

2.3.3 Copulation

Mating usually occurs on vegetation within 1 m of the water, in the vicinity of the male's territory. The male

lands on the proximal end of the female's wings and walks forward onto her prothorax. Sperm translocation immediately follows tandem formation. As soon as mating in the typical odonate "wheel position" ends, the male returns to his usual perch; the female remains perched nearby for a short time, then may leave briefly (Conrad and Herman 1987).

2.3.4 Oviposition

The female lands on the vegetation selected for egg-laying and probes beneath the water with her abdomen. Eggs are laid endophytically. Usually only the tip of the abdomen is submerged, but occasionally the female submerges entirely by slowly backing down the vegetation, sometimes deeper than 20 cm (Conrad and Herman 1987). According to Martin (1939), females descended "a foot or more" beneath the water and often remained underwater for 30 minutes or more. During oviposition, the male remains nearby and guards against intruding males (Conrad and Herman 1987). In Christina Creek, the females laid eggs in Illinois pondweed (*Potamogeton illinoensis*; Cannings et al. 1999).

2.4 Survival

No information.

2.5 Physiology

No information.

2.6 Movements/Dispersal

In a Nova Scotia study, adult females were constantly vagile; males were site-specific, but occasionally moved long distances between captures. Immigrants accounted for a large proportion of the population after 20 June (Conrad and Herman 1990).

2.7 Nutrition and Interspecific Interactions

Both adults and larvae are predaceous on small invertebrates.

2.8 Behaviour/Adaptability

For a description of territorial and courtship behaviour, see Section 2.3 (Reproduction).

3 HABITAT

3.1 Habitat Requirements

Larvae live in small to medium-sized, warm rivers and streams (Walker 1953; Conrad and Herman 1987; Cannings 2002). Christina Creek drains Christina Lake, which attains a maximum surface temperature of 25°C in early August (Cavanagh et al. 1994). Females oviposit in submerged aquatic vegetation (Conrad and Herman 1987); in eastern Canada, females prefer bur-reed (*Sparganium* spp.; Walker 1953).

3.2 Trends in Habitat Quality and Quantity

The habitat surrounding Christina Creek has remained relatively unchanged (R. Walker, pers. comm.). However, introduced fish and Eurasian water-milfoil (*Myriophyllum spicatum*) may have reduced the habitat suitability for *Calopteryx* (see Section 6.4, Exotic Species). No declines in water quality in the Christina Lake system were noted in the 20 years preceding 1994 (Cavanagh et al. 1994).

3.3 Present Habitat Status

The status of the foreshore is mostly natural; it is lined by riparian vegetation typical of the area: water birch (*Betula occidentalis*), paper birch (*B. papyrifera*), alder (*Alnus tenuifolia*), red-osier dogwood (*Cornus stolonifera*), wild roses (*Rosa* spp.) and Pacific ninebark (*Physocarpus capitatus*). This is one of the last undeveloped lowland riparian habitats in the Christina Lake area (R. Walker, pers. comm.). Clumps of *Potamogeton illinoensis*, an aquatic plant that is rare in British Columbia, are scattered along the river's edge.

The habitat undoubtedly has been altered by the introduction of Eurasian water-milfoil, which, according to the Okanagan Similkameen Boundary Fisheries Partnership (2002), is getting out of control, especially at the south end of the lake and in the mouth of Christina Creek. The habitat suitability has also probably declined with the arrival of several species of exotic fish (see Section 6.4, Exotic Species).

3.4 Protection/Ownership

None of the surrounding land is formally protected. Much of the land surrounding the northern half of

Christina Creek south of Highway 3 is in District Lot 498, a Crown-owned parcel in Government Reserve. The lot immediately to the south on the east bank is DL 315, a parcel owned privately by an individual who is interested in preserving the natural values of the land and river foreshore. The Nature Conservancy of Canada is working with all the landowners along the creek to establish conservation covenants on the various lots (K. Blake, pers. comm.).

4 DISTRIBUTION

4.1 Global/North American

Distributed broadly across northern and central North America (Figure 2) from extreme southern British Columbia and north-central Alberta east to Newfoundland and Nova Scotia, south to California, Nevada, Colorado, Nebraska, Indiana, Iowa and Virginia (N. Donnelly, pers. comm.; Westfall and May



Figure 2. Rangewide distribution of *Calopteryx aequabilis* (from N. Donnelly, pers. comm.; Walker 1953; Westfall and May 1996; Nunnallee and Paulson 2002).

1996). Westfall and May (1996) list the Northwest Territories in the species' range, but evidence for this record has not been found. In the west, the distribution is spotty, especially in areas with a drier climate (Figure 3). In Washington, it is described as "locally common" in the lowlands, mostly in the south, and more common east of the Cascade Mountains (Paulson 1999). The nearest known locality to the Christina Creek, British Columbia site is about 75 km southeast at "Camas Creek," 7.5 km south of Springdale, Washington (D. Paulson, pers. comm.).

4.2 British Columbia

In British Columbia, this species is known only from Christina Creek, between Christina Lake and the Kettle River (Cannings et al. 1999). There is an unsubstantiated sight record from the Kettle River (R.J. Cannings, pers. comm.).

5 POPULATION SIZES AND TRENDS

5.1 Population Size

The Christina Creek population is not large; the maximum count along the creek was 25 males and three



Figure 3. Known county distribution of *Calopteryx aequabilis* in the western United States (Nunnallee and Paulson 2002).

females on 19 July 1999 (L.R. Ramsay, pers. comm.). Many adults may not be in attendance at any one time, but the adult total is probably less than 1000 and perhaps significantly less than that.

5.2 Population Trends

Since the Christina Creek population was only discovered in 1999, there are no longer-term data that might give trend information.

6 LIMITING FACTORS AND THREATS

6.1 Limiting Factors

In British Columbia, available habitat is definitely limiting; relatively few rivers in the southern interior flow clear, slow and warm, as Christina Creek does. The Okanagan River would seem to be appropriate; why this species does not occur there is unknown. In Christina Creek, the limiting factors for this species

are probably the availability of oviposition sites and predation by introduced fish.

6.2 Habitat Loss/Degradation

One of the major threats at Christina Creek is potential foreshore development. The eastern banks of the river are undeveloped and are a mix of Crown land (Government Reserve) and land owned at present by conservation-minded owners. The western banks are more open to development. However, the Nature Conservancy of Canada is currently negotiating with the owners to protect foreshore riparian habitat through conservation covenants (K. Blake, R. Durand, pers. comm.).

6.3 Pollution/Pesticides

Groundwater contaminated with domestic waste is a significant concern in Christina Lake. This would have a eutrophication effect on the system; however, in



Figure 4. British Columbia distribution of *C. aequabilis* (Christina Creek).

1994, the lake was still considered oligotrophic, with clear water of high quality. No trend in declining water quality was detected. Logging also has the potential to increase sediment phosphorus and nitrogen flowing into tributaries to the lake. Because of the steep terrain, runoff from logging is a potential concern, as is runoff from abandoned metal mines (Cavanagh et al. 1994).

No information is available on the effects of pesticides on this species. Pesticides from the residential and recreational properties along the southern shores of Christina Lake are a potential problem.

6.4 Exotic Species

Although no trend data are available, it would seem likely that the arrival of the exotic Largemouth Bass (*Micropterus salmoides*), Smallmouth Bass (*M. dolomieu*), Pumpkinseed (*Lepomis gibbosus*), Yellow Perch (*Perca flavescens*) and Carp (*Cyprinus carpio*) caused a substantial decline in odonate larval density in Christina Creek. These exotic species have apparently entered Christina Creek primarily via introductions into Roosevelt Lake, the reservoir above the Grand Coulee Dam, south of the U.S. border (L. Brazier, B. Jantz, pers. comm.).

Fish are major predators of odonate larvae (Hilton 1987; Corbet 1999). In an experimental study in North Carolina, 10 times as many dragonfly larvae were found within fish exclusion cages as outside them (Morin 1984). In an Iowa study, odonate larvae made up 62-70% of the food of Largemouth Bass greater than 9 cm long (Wright 1946). In Minnesota, coenagrionid damselfly and libellulid dragonfly larvae were prominent among food of *Lepomis* sunfish (Crowder and Cooper 1982). In Tennessee, *Lepomis* sunfish preyed heavily on the larvae of *Epitheca cynosura* (a medium-sized corduliid dragonfly); the mean number of larvae per fish when caught was 30 (Martin 1986).

The habitat structure within Christina Creek is also changing with the increase in Eurasian water-milfoil. This plant is abundant primarily at the outlet of the lake; its density or occurrence in the creek is probably much less. The direct and indirect effects of this exotic plant on *C. aequalis* are unknown.

6.5 Recreation Impacts

Of particular concern is the use of personal watercraft along a narrow stream such as Christina Creek. The

wakes from these craft break down the banks (observed directly at Christina Creek) and ultimately collapse the streamside vegetation (Cannings et al. 1999).

7 SPECIAL SIGNIFICANCE OF THE SPECIES

This is the only member of its family in British Columbia. As one of only a handful of odonates that occur in flowing water in the province, the species could be a good indicator of lowland stream health.

8 EXISTING PROTECTION OR OTHER STATUS

There is no protection offered to invertebrates in British Columbia. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has not yet assessed dragonflies; therefore, this species has not been given other status by COSEWIC and, by extension, does not have status under the federal *Species at Risk Act*. Nor has it been given other status under the U.S. *Endangered Species Act*. It is given a global rank of G5 by NatureServe, indicating that it is widespread and unlikely to be of conservation concern (NatureServe 2002). Because of its extremely restricted distribution in British Columbia, it is assigned a provincial conservation status rank of S1 and placed on the Red List of species of conservation concern (BCCDC 2003).

9 RECOMMENDATIONS AND MANAGEMENT OPTIONS

9.1 Inventory and Research

The Kettle River has not been well surveyed and may also host a population of this species. More precise counts along Christina Creek are needed to establish baseline population numbers and to determine if any trends are evident. Monitoring of the Christina Creek population should be relatively easy and probably could be done by organized, trained amateurs.

9.2 Riparian Zone Management

The protection of riparian zones is probably vital. Shrubs and trees in these zones not only provide resting

sites and cover for adult damselflies, but also protect the stream banks from erosion and contribute to in-stream structure. Samways and Steytler (1996) provide recommendations for the width of riparian buffers and vegetation heterogeneity for odonate species assemblages. Although these recommendations do not directly treat *C. aequabilis*, the life requirements of the dragonfly species are similar; these recommendations therefore may be used as starting points for a management plan for this species.

On Christina Creek, protection of riparian vegetation communities is being actively pursued by The Nature Conservancy of Canada through the creation of conservation covenants on the private land parcels along the stream.

9.3 Recreation Management

Control of the amount and type of recreation in the habitat is also important. The unique qualities of Christina Creek should be recognized in any recreation regulations or guidelines concerning it. As mentioned in Section 6 (Limiting Factors and Threats), the use of personal watercraft along this stream is of particular concern (Cannings et al. 1999).

9.4 Introduced Species Management

Because introduced fish have undoubtedly had a negative impact on dragonfly larval density, one would expect that any control of fish abundance would have a positive effect on the *C. aequabilis* population.

Control of Eurasian water-milfoil is also a concern. However, extreme care must be taken not to remove the native vegetation used by *C. aequabilis* as oviposition sites when removing Eurasian water-milfoil.

9.5 Pollution Control

Because of the unique qualities of Christina Creek (especially the presence of rare aquatic plants and invertebrates), extra precautions should be taken to prevent pesticide or other pollution, or eutrophication of the watershed.

10 EVALUATION

10.1 Conservation Data Centre Ranking

Number of Occurrences: A

Only one known occurrence; perhaps one or two more exist.

Number of Occurrences with Good Viability: AB

0-1; more detailed studies need to be done to estimate the viability of the only known occurrence.

Population Size: BC

Again, no thorough inventories have been made to attempt to estimate population size, but it probably is more than 50 and less than 1000.

Range – Extent of Occurrence: A

Christina Creek is about 4 km long.

Area of Occupancy: LA

Christina Creek is about 4 km long and averages about 7-10 m wide.

Short-term Trend in Population Size, Extent of Occurrence, Area of Occupancy, and/or Number or Condition of Occurrences: U

Unknown.

Long-term Trend in Population Size, Extent of Occurrence, Area of Occupancy, and/or Number or Condition of Occurrences: U

Unknown; only discovered in 1999.

Threats: A

Scope: High (>60% of population or area affected) for introduced fish and Eurasian water-milfoil; Moderate (5-20% affected) for habitat loss/degradation.

Severity: Moderate (major reduction of species population, or long-term degradation or reduction of habitat in area affected) in terms of introduced fish and aquatic plants.

Imminence: High for introduced fish and Eurasian water-milfoil; Moderate for habitat degradation.

Number of Appropriately Protected and Managed Occurrences: A

Habitat not formally protected.

10.2 Summary

Because this species is known to occur along only one short watercourse in the province (Christina Creek) and because this site is not secured, I recommend maintaining the provincial ranking of S1 (BCCDC 2003) and consequent Red-listing. Although there is a possibility that other populations exist, especially along the Kettle River, the probability is very small that these populations would be large or extensive

enough to change the rank to another value. The threats posed by exotic fish and Eurasian water-milfoil, inappropriate recreation use, potential riparian development and pollution are also of concern in this unique stream system.

11 AUTHORITIES CONSULTED

- Katie Blake, Nature Conservancy of Canada, Victoria, BC
 Leo Brazier, Grand Forks, BC
 Jay Cordeiro, NatureServe, Boston, MA
 Ryan Durand, Turtle Island Earth Stewards, Victoria, BC
 Robert Cannings: Royal British Columbia Museum, Victoria, BC
 Brian Jantz, Penticton, BC
 Jim Johnson: Vancouver, WA
 Dennis Paulson: University of Puget Sound, Tacoma, WA
 Leah Ramsay, Conservation Data Centre, MSRM, Victoria, BC
 Steve Valley: Albany, OR

12 LITERATURE CITED

- Bick, G.H., and J.C. Bick. 1981. Heterospecific pairing among Odonata. *Odonatologica* 10:259-270.
- British Columbia Conservation Data Centre (BCCDC). 2003. British Columbia Species Explorer. B.C. Minist. Sustainable Resour. Manage. and B.C. Minist. Water, Land and Air Prot., Victoria, BC. Available at: <http://srmwww.gov.bc.ca/atrisk/toolintro.html>. Accessed 13 Jan 2003.
- Cannings, R.A. 2002. Introducing the dragonflies of British Columbia and the Yukon. Royal B.C. Mus., Victoria, BC. 96pp.
- _____, S.G. Cannings, and L.R. Ramsay. 1999. The dragonflies (Insecta: Odonata) of the Columbia Basin, British Columbia: field surveys, collections development and public education. Living Landscapes prog., Royal B.C. Mus., Victoria, BC. Unpubl. rep. Available at: http://livinglandscapes.bc.ca/www_dragon/toc.html. Accessed 15 Dec 2002.
- Cavanagh, N., R. Nordin, and J. Bryan. 1994. Ambient water quality assessment and objectives for Christina Lake. B.C. Minist. Environ., Lands and Parks, Water Manage. Branch, Victoria, BC. Available at: <http://wlapwww.gov.bc.ca/wat/wq/objectives/christina/christina.html#hydrology>. Accessed 13 Jan 2003.
- Conrad, K.F., and T.B. Herman. 1987. Territorial and reproductive behaviour of *Calopteryx aequabilis* Say (Odonata: Calopterygidae) in Nova Scotia, Canada. *Adv. in Odonatology* 3:41-50.
- _____, and _____. 1990. Seasonal dynamics, movements and the effects of experimentally increased female densities on a population of imaginal *Calopteryx aequabilis* (Odonata: Calopterygidae). *Ecol. Entomol.* 15:119-129 [*Odonatological Abstr.* 7276].
- Corbet, P.S. 1999. Dragonflies: behavior and ecology of Odonata. Comstock Publ. Assoc., Cornell Univ. Press, Ithaca, NY. 829pp.
- Crowder, L.B., and W.E. Cooper. 1982. Habitat structural complexity and the interactions between bluegills and their prey. *Ecology* 63:1802-1813.
- Hilton, D.F.J. 1987. Aquatic insects of peatlands and marshes in Canada. *Mem. Entomol. Soc. Can.* 140:57-63.
- Martin, R.D.C. 1939. Life histories of *Agrion aequabile* and *Agrion maculatum* (Agridae: Odonata). *Ann. Entomol. Soc. Am.* 32:601-615.
- Martin, T.H. 1986. The diets of bluegill and redear sunfish in Bay's Mountain Lake. MSc Thesis, E. Tennessee State Univ., Johnson City, TN.
- Meek, S.B., and T.B. Herman. 1990. A comparison of the reproductive behaviours of three *Calopteryx* species (Odonata: Calopterygidae) in Nova Scotia. *Can. J. Zool.* 68:10-16.
- Morin, P.J. 1984. The impact of fish exclusion on abundance and species composition of larval odonates: results of short-term experiments in a North Carolina farm pond. *Ecology* 65:53-60.

- NatureServe. 2002. Element occurrence specifications: riverine dragonflies. BioTics Tracker database, 15 Dec 2002; information available through B.C. Minist. Sustainable Resour. Manage., Conserv. Data Centre, Victoria, BC.
- Nunnallee, D., and D. Paulson. 2002. Western U.S. Odonata range maps. Available at: <http://www.ups.edu/biology/museum/westernOD.html>. Accessed 18 Dec 2002.
- Okanagan Similkameen Boundary Fisheries Partnership. 2002. Okanagan Similkameen Boundary Fisheries Partnership Watershed Weekly, 6/13 Sep 2002. Available at: [http://www-heb.pac.dfo-mpo.gc.ca/english/programs/hcsp/areas/nwsltr/bcis/OSBFP.htm#TOP\(sep6\)](http://www-heb.pac.dfo-mpo.gc.ca/english/programs/hcsp/areas/nwsltr/bcis/OSBFP.htm#TOP(sep6)). Accessed 9 Jan 2003.
- Paulson, D. 1999. Dragonflies of Washington. Seattle Audubon Soc., Seattle, WA. 32pp.
- Samways, M.J., and N.S. Steytler. 1996. Dragonfly (Odonata) distribution patterns in urban and forest landscapes, and recommendations for riparian management. *Biol. Conserv.* 78:279-288.
- Schorr, M., M. Lindeboom, and D. Paulson. 2002. List of Odonata of the world (Part 1, Zygoptera and Anisozygoptera). Revised 7 Nov 2002. Available at: <http://www.ups.edu/biology/museum/worldodonates.html>. Accessed 3 Dec 2002.
- Walker, E.M. 1953. The dragonflies of Canada and Alaska, Vol. 1. Univ. Toronto Press, Toronto, ON. 292pp.
- Westfall, M.J., and M.L. May. 1996. Damselflies of North America. Scientific Publ., Gainesville, FL. 649pp.
- Wright, M. 1946. The economic importance of dragonflies (Odonata). *J. Tennessee Acad. Sci.* 21:60-71.